-	170	((((((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)) and ("silicon oxide" "silicon nitride")) and (insulator insulating)) and (film near forming)) and silicon	USPAT	2002/04/15 15:42
-	91	(((((((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)) and ("silicon oxide" "silicon nitride")) and (insulator insulating)) and (film near forming)) and silicon) and (water H2O)	USPAT	2002/04/15 15:47
-	60	(((((((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)) and ("silicon oxide" "silicon nitride")) and (insulator insulating)) and (film near forming)) and silicon) and (water H2O)) and "silicon nitride" and "silicon oxide"	USPAT	2002/04/16 11:44
-	23	(((((((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)) and ("silicon oxide" "silicon nitride")) and (insulator insulating)) and (film near forming)) and silicon) and (water H2O)) and "silicon nitride" and "silicon oxide" and "hydrogen peroxide"	USPAT	2002/04/16 12:49
-	3780	((ammonia hydrazine amine NH3) and ("hydrogen peroxide" H2O2)) and ("dangling bonds" "hydroxyl groups" "interface bonds")	USPAT	2002/04/16 12:52
-	100	(((ammonia hydrazine amine NH3) and ("hydrogen peroxide" H2O2)) and ("dangling bonds" "hydroxyl groups" "interface bonds")) and "silicon nitride"	USPAT	2002/04/16 12:53
-	47	((((ammonia hydrazine amine NH3) and ("hydrogen peroxide" H2O2)) and ("dangling bonds" "hydroxyl groups" "interface bonds")) and "silicon nitride") and "silicon oxide"	USPAT	2002/12/03 16:33
-	2565	(ammonia NH3) same ("hydrogen peroxide" H2O2)	USPAT	2002/12/03 16:35
-	467	((ammonia NH3) same ("hydrogen peroxide" H2O2)) and ("silicon oxide" "silicon nitride")	USPAT	2002/12/03 16:35
-	1541	(ammonia NH3) with ("hydrogen peroxide" H2O2)	USPAT	2002/12/03 16:35
-	407	((ammonia NH3) with ("hydrogen peroxide" H2O2)) and (((ammonia NH3) same ("hydrogen peroxide" H2O2)) and ("silicon oxide" "silicon nitride"))	USPAT	2002/12/03 16:36
-	239	(((ammonia NH3) with ("hydrogen peroxide" H2O2)) and (((ammonia NH3) same ("hydrogen peroxide" H2O2)) and ("silicon oxide" "silicon nitride"))) and @py<2000	USPAT	2002/12/03 16:41
-	201	((((ammonia NH3) with ("hydrogen peroxide" H2O2)) and (((ammonia NH3) same ("hydrogen peroxide" H2O2)) and ("silicon oxide" "silicon nitride"))) and @py<2000) and heat$3	USPAT	2002/12/04 09:53
-	0	((((ammonia NH3) with ("hydrogen peroxide" H2O2)) and (((ammonia NH3) same ("hydrogen peroxide" H2O2)) and ("silicon oxide" "silicon nitride"))) and @py<2000) and heat$3 and (HNO3 Nitric Acid)	USPAT	2002/12/04 09:54

-	0	((((ammonia NH3) with ("hydrogen peroxide" H2O2)) and (((ammonia NH3) same ("hydrogen peroxide" H2O2)) and ("silicon oxide" "silicon nitride"))) and @py<2000) and heat$3 and (HNO3 Nitric Acid)	US-PGPUB; EPO; JPO	2002/12/04 09:54
-	125951	"silicon oxide" SiO SiO2	USPAT; EPO; JPO	2003/05/28 22:40
-	17481	(treat$3 contact$3 surface) adj10 ("silicon oxide" SiO SiO2)	USPAT; EPO; JPO	2003/05/28 22:41
-	208	((treat$3 contact$3 surface) adj10 ("silicon oxide" SiO SiO2)) same (HNO3 NO3 NO2 "nitric acid" H2O2 "hydrogen peroxide")	USPAT; EPO; JPO	2003/05/28 22:44
-	94	(((treat$3 contact$3 surface) adj10 ("silicon oxide" SiO SiO2)) same (HNO3 NO3 NO2 "nitric acid" H2O2 "hydrogen peroxide")) and cvd	USPAT; EPO; JPO	2003/05/28 22:44

		and ... ...; and cover) and wafer		15:23
-	245960	ammonia hydrazine amine NH3	USPAT	2002/04/15 14:58
-	1751	(ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)	USPAT	2002/04/15 14:59
-	1369	((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)	USPAT	2002/04/15 15:00
-	796	(((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)) and ("silicon oxide" "silicon nitride")	USPAT	2002/04/15 15:01
-	593	((((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)) and ("silicon oxide" "silicon nitride")) and (insulator insulating)	USPAT	2002/04/15 15:39

				15:16
-	170	(((((ammonia hydrazine amine NH3) and (tetraethylorthosilicate TEOS)) and ("hydrogen peroxide" ozone oxygen "nitric acid" "sulfuric acid" H2O2 O3 H2SO4)) and ("silicon oxide" "silicon nitride")) and (insulator insulating)) and (film near forming)	USPAT	2002/04/16 12:50

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Title
The particle contamination during wet cleaning process onto various wafer surfaces.

Author(s)
Sakata-Y; Ohnishi-A; Kishi-G; Izumo-S; Kondou-H; Tomozawa-A; Ed. by Novak-R-E; Ruzyllo-J.

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P Practical; X Experimental.

Abstract
As the scale of integration increases, it is increasingly important to reduce particle contamination of the wafer surface during VLSI fabrication. During sub- mu m VLSI manufacture, RCA cleaning solutions such as APM **(ammonia/hydrogen peroxide** mixture) or HPM (hydrochloride **/hydrogen peroxide** mixture) are widely used after the photoresist- ashing process, continuing from dry etching or ion implantation in order to remove particles from wafer surfaces. There are many kinds of wafer surface in a 0.5 mu m process fabrication line other than the Si wafer, including wafers on which SiO/sub 2/ (thermal or **CVD),** Si/sub 3 /N/sub 4/ or polysilicon (metal) films are deposited. We found that the number of particles on a wafer surface during wet cleaning depended on the state of the wafer surface. In particular, Si/sub 3/N /sub 4/-deposited wafers are the most sensitive to contamination relative to the other wafers, i.e. the number of particles on a Si/sub 3/N/sub 4/ wafer after RCA cleaning is much greater than that for SiO /sub 2/ wafers. We also found that the number of particles on a Si/sub 3/N/sub 4/ wafer surface depended on the electrical capacitance of the Si/sub 3/N/sub 4/ film. These particles come from the back side of other wafers, diffuse into the etchant, and re-adhere to the wafer front side of wafers. We observed this phenomenon mainly when RCA cleaning was applied in normal order, i.e. HPM to APM. When

the order of RCA cleaning was reversed to APM to HPM, the number of particles decreased, even on Si/sub 3/N/sub 4/ wafers. Wafer particle distribution depended on liquid flow in the cleaning vessel. We analyze these phenomena in this paper, using the zeta potential of the films. (4 refs).

Descriptors

capacitance; electrokinetic-effects; etching; integrated-circuit-reliability; integrated-circuit-testing; integrated-circuit-yield; surface-cleaning; surface-contamination; VLSI.

Keywords

particle contamination; wet cleaning process; wafer surfaces; integration scale; VLSI fabrication; RCA cleaning solutions; **ammonia hydrogen peroxide** mixture; hydrochloride **hydrogen peroxide** mixture; photoresist ashing; dry etching; ion implantation; particle removal; Si wafer; SiO2 films; Si3N4 films; polysilicon films; Si3N4 deposited wafers; contamination sensitivity; electrical capacitance; particle count; cleaning vessel liquid flow; wafer particle distribution; Si; SiO2 Si; Si3N4 Si; NH3 H2O2; HCl H2O2.

Classification codes

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B2550E    (Surface treatment for semiconductor devices).
B0170E    (Production facilities and engineering).
B2570     (Semiconductor integrated circuits).
B0170N    (Reliability).
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Chemical indexing

Si int, Si el; SiO2-Si int, SiO2 int, O2 int, Si int, O int, SiO2 bin, O2 bin, Si bin, O bin, Si el; Si3N4-Si int, Si3N4 int, Si3 int, N4 int, Si int, N int, Si3N4 bin, Si3 bin, N4 bin, Si bin, N bin, Si el; Si sur, Si el; NH3H2O2 ss, H2 ss, H3 ss, O2 ss, H ss, N ss, O ss; HCl H2O2 ss, Cl ss, H2 ss, O2 ss, H ss, O ss.

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